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NATIONAL BUREAU OF STANDARDS

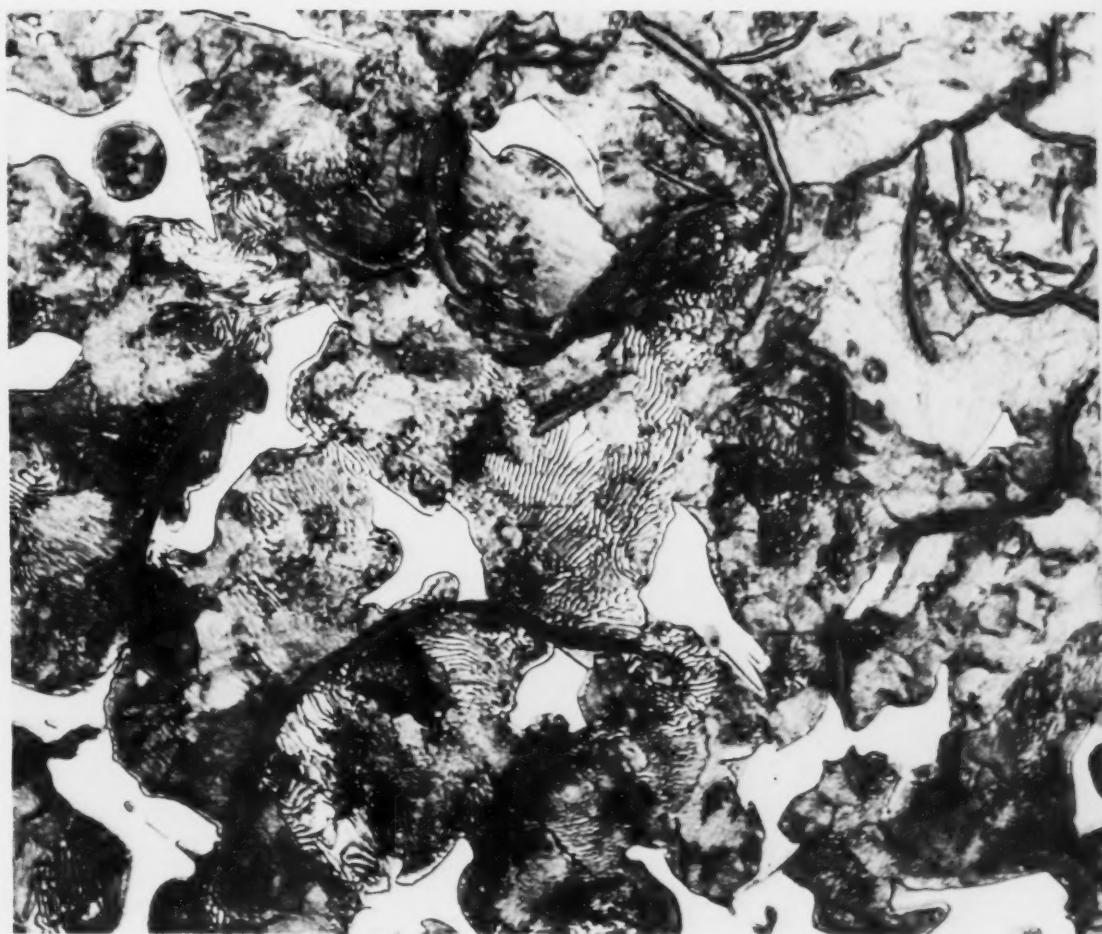
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# Technical News Bulletin

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NATIONAL BUREAU OF STANDARDS

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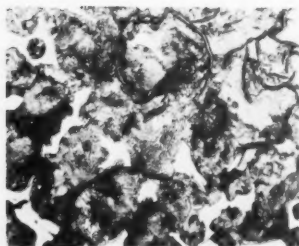
Alexander B. Trowbridge  
Secretary

NATIONAL BUREAU OF STANDARDS

A. V. Astin, Director

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## COVER

Photomicrograph showing a metallic microstructure used to "fingerprint" metal objects (X750). A technique recently developed for the U.S. Arms Control and Disarmament Agency uses the sizes, shapes, and interrelationships of the grain boundaries and phase particles as identifying characteristics. (See p. 224.)

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- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

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# QUANTITATIVE EVALUATION OF COLOR INDUCTION

*G. Yonemura looks at two fixed surrounds of different colors and a fixed target centrally located in one of them. He is attempting to select a target for the other surround so as to make the two target-color perceptions identical.*



■ Since before the time of Leonardo da Vinci, the influence of a surrounding color on a centrally located color has been well known qualitatively. A red surround makes a central field or target appear greener; the converse is also true. In the same manner a yellow surround induces blue in the target and a white surround darkens the target. This color induction is dealt with daily by artists, interior decorators, advertisers, and stage designers, who usually rely on a trial-and-error solution to the problem.

To determine color induction quantitatively, H. Takasaki,\* of the NBS Institute for Basic Standards, recently conducted a two-year study of color-surround influence.<sup>1</sup> This study was intended as a first step toward a quantification of the factors involved in color design. Such work may eventually make it possible to compute precisely the colors required to carry out a basic idea for a decoration scheme, in the same manner as an engineer computes the strength required for each element of a bridge to carry out the basic idea of its design.

Color induction occurs not only when an observer looks back and forth from target to surround, but also when he looks only at the target. The first condition is called successive color contrast; the latter is known as simul-

taneous color contrast. The effect on an observer is similar in both cases. Color induction in scanning a scene is thought to be some combination of the two processes.

In the NBS study an observer was presented with a target, surrounded by a fixed color. Beside this target-surround combination was a second combination with a surround of fixed color different from that of the first. The observer then selected a target for the second surround such as to make the two target-color perceptions identical.

In experiments with grays it was found that substitution of a black (Munsell value 1/) surround for a white (Munsell value 9/) surround made a middle gray (Munsell value 5/) target appear as if its Munsell value had been raised by 2 to 4 Munsell value steps, depending on the observer; that is, a reduction of 8 Munsell value steps in the surround raised the perceived lightness of the target by one-half to one-fourth of the color difference between the two surrounds.

Use of gray surrounds of Munsell value different from 1/ and 9/, and use of gray targets of Munsell value different from 5/, revealed a rather complicated but regular dependence of Munsell-value induction on the two fixed surrounds and the fixed target. Dr. Takasaki found that if the perceived lightnesses ( $L_i$ ) of the two targets are set equal to:

$$L_i = V_i - C_1 V_{b1} + C_2 \bar{V}_b \left[ \frac{(V_i - V_{b1})}{C_3} \right] e^{-|V_i - V_{b1}|/C_3},$$

$i=1,2$ ,  $V$  is the Munsell value of the target,  $V_b$  is the Munsell value of the surround, and  $\bar{V}_b$  is the average Munsell value for the two surrounds, then the Munsell value found experimentally for the second target corresponds closely to the Munsell value  $V_2$  which makes  $L_2=L_1$  by the above empirical formula.  $C_1$ ,  $C_2$ , and  $C_3$  are constants which must be adjusted to fit the data obtained for each observer separately. The third term of this empirical formula

Now at the University of Shizuoka, Japan.

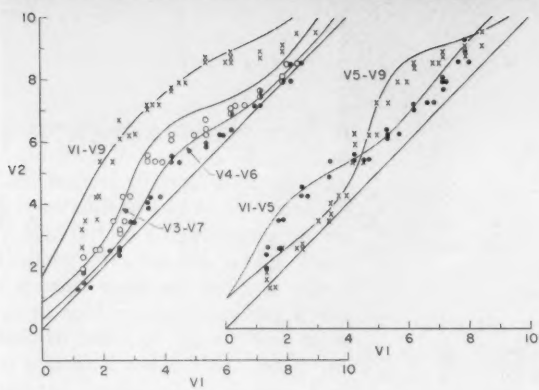
*continued*  
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## COLOR INDUCTION *continued*

(the one having the form  $\Delta V e^{-|\Delta V|}$ ) corresponds to the verification of an inductive effect not previously recognized. Curves corresponding to computations from the empirical formula agree well with the plotted points found by visual observation.

Very small color differences cause by far the greatest influence per unit color difference between surround and target. This induction effect has been named the "crispening" effect because by this effect small gradients in color are magnified. In the equation the constant  $C_1$  corresponds to general induction;  $C_2$ , to amount of crispening; and  $C_3$ , to reciprocal sharpness of crispening.

Experiments with two chromatic series of constant lightness, a red-green and a violet-yellow green series, confirmed the existence of crispening for chromatic induction as well as for light-dark induction. Chromatic crispening, however, is at the same time of lesser amount and sharper than lightness crispening, and much sharper for the red-green series.



*These plots of data show the agreement between an empirical formula (smooth curves) and experimental observations of an observer (plotted points). The Munsell value,  $V_1$ , of a fixed target surrounded by a gray background is the abscissa. The ordinate,  $V_2$ , is the Munsell value of a second target surrounded by a different gray background. The data were obtained by having an observer attempt to match the two targets. The distance of the curves above the 45° line indicates the amount of induction. Each curve is labeled according to the Munsell values of the two gray backgrounds.*

Information on color crispening (lightness crispening plus chromaticness crispening) is of obvious value in the solution of the problem of selecting a series of colors that will appear equally spaced when viewed against a background of any arbitrarily selected color. To appear equally spaced, the

colors differing only slightly from the surround color must be more closely spaced than those greatly different from it.

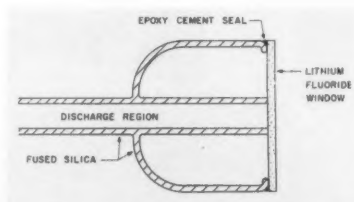
<sup>1</sup> Lightness change of grays induced by change in reflectance of gray background, by H. Takasaki, J. Opt. Soc. Am. 56, 504 (1966). See also, Chromatic changes induced by changes in chromaticity of background of constant lightness, by H. Takasaki, J. Opt. Soc. Am. 57, 93 (1967).

## VACUUM ULTRAVIOLET RESONANCE LAMPS IMPROVED

■ Rare-gas ultraviolet resonance lamps are widely used in vacuum ultraviolet photolysis. A problem commonly encountered in these lamps, however, is that of attaching lithium fluoride windows to the lamp body. Frequently the lamp discharge causes decomposition of the sealing compound between the lamp window and lamp body, resulting in the coating of the window by decomposition products.

This difficulty can be eliminated by using a simple modification devised by A. M. Bass of the NBS Institute for Basic Standards in work supported by the National Aeronautics and Space Administration. In this modification, the window is not sealed directly to the end of the discharge tube; instead, it is sealed to a larger tube concentric with the discharge tube. The larger tube is attached to the lamp and cut so that the ends of the two tubes are coplanar.

In operation of the modified lamp, the discharge is confined to the inner tube. The window seal is thus removed from the discharge area and is protected from it by the inner tube. Tests at the 100 percent power level of a 125-watt, 2450-MHz microwave generator have shown that with the modified design the seal remains completely unaffected by lamp operation.



*Schematic drawing of the NBS modification to vacuum ultraviolet resonance lamp design.*

# OXIDE-TYPE CRYSTALS GROWN BY ZONE MELTING

■ Single crystals of calcium molybdate were recently grown by the temperature gradient zone melting technique at the NBS Institute for Materials Research. This work,<sup>1</sup> by H. S. Parker and W. S. Brower, Jr., had two objectives. The first was to evaluate and develop more fully this technique of growing crystals at temperatures below the crystal's melting point. The second was to demonstrate experimentally that oxide-type, single crystals prepared by this technique could be of equal or greater perfection than those grown by other techniques.

The calcium molybdate crystals grown by the temperature-gradient zone-melting technique were compared to crystals pulled from the melt in the conventional manner. This comparison showed that the density of etch pits in the crystals prepared by temperature-gradient zone melting was less by an order of magnitude than those pulled from the melt—approximately  $5 \times 10^3/\text{cm}^2$  versus  $5 \times 10^4/\text{cm}^2$ .

Single crystals that are of highest chemical purity, and physically as free from defects as possible, are necessary in studying the properties of materials. Such crystals are not always easily grown at temperatures near the melting point for several reasons, including phase changes, high vapor pressure, and the formation of lattice defects during growth as a result of the high temperatures involved.

The temperature-gradient zone-melting technique used in this study was originally proposed in 1955 as a possible technique to produce chemically pure materials and single crystals for the semiconductor industry.<sup>2</sup> Basically, the technique uses a three-part "sandwich" consisting of a single crystal seed, a thin zone of molten material, and a layer of source material. The source material is usually of the same composition as the seed while the liquid zone is a solution of the source material and a solvent. The "sandwich" is placed in a temperature gradient with the source material at the highest temperature. This temperature is below the melting point of the source. The lowest temperature in the system is above the eutectic temperature of the mixture in the zone.

Under these conditions both the seed crystal and the source dissolve into the molten zone forming a saturated solution at each interface. As the concentration of the

dissolved materials will be greater at the source or hot side of the zone, the material will diffuse through the zone to the cooler side creating a supersaturated condition next to the seed.

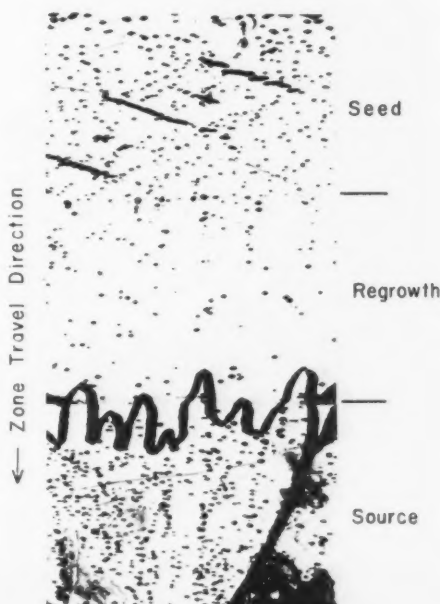
The supersaturated state is unstable and causes the material to precipitate onto the seed crystal. The loss of material from the solution causes additional material to dissolve from the source. This material in turn diffuses through the zone to the seed with the result that continuous growth occurs on the seed.

Messrs. Parker and Brower chose calcium molybdate (m.p.  $>1400^\circ\text{C}$ ) as the experimental material because it is of general technical interest, because single crystals of this material grown by other methods were available for comparison, and because a supply of these crystals was available for use as seeds in the growth experiments. The initial zone composition was the eutectic mixture of calcium molybdate and lithium sulfate with a composition of 85 weight percent of  $\text{LiSO}_4$  and 15 weight percent of  $\text{CaMoO}_4$ . The temperature gradient in the "sandwich" during the experiments ranged from  $830$  to  $960^\circ\text{C}$ .

<sup>1</sup> For further information, see *Growth of calcium molybdate crystals by a temperature gradient zone melting technique*, by H. S. Parker and W. S. Brower, Jr., *Crystal Growth*, Suppl. to *J. Phys. Chem. Solids*, 489-491 (1967).

<sup>2</sup> *Temperature gradient zone melting*, by W. G. Pfann, *Trans. AIME* 203, 961 (1955).

*The polished and etched section of a  $\text{CaMoO}_4$  single crystal shows a reduction in etch pit density in the area of regrowth as compared to the seed area.*





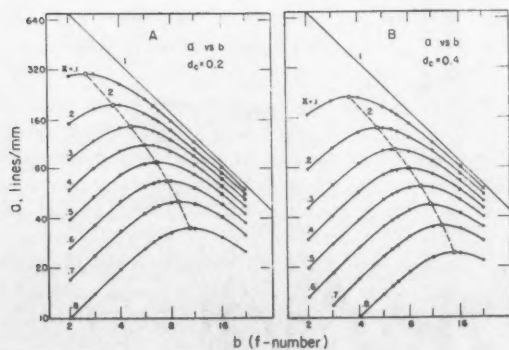
# ACCURATE PREDICTION OF LENS RESOLVING POWER

Many scientific studies utilize photography as a means of obtaining and interpreting data. Applications include lunar photography, aerial photography, stop-motion investigations of moving objects, and many others. In many of the photographic systems used in these studies, however, optimum resolving power has not been obtained because realistic data were not available with which to predict lens resolving power.

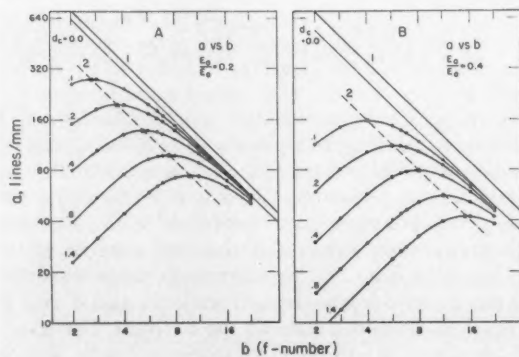
To aid the many users of photographic systems, F. E. Washer of the NBS Institute for Basic Standards has devised a technique for predicting lens resolving power that gives good agreement with measured values.<sup>1</sup> The method can be used to prepare tables of lens resolving power at selected values of  $X$  (relative contrast) for a series of values of  $f$ -number (relative aperture) and longitudinal chromatic aberration ( $d_c$ ). This work is expected to eliminate some of the uncertainty in designing photographic systems, and to provide lens manufacturers with a means to accurately evaluate resolving power.

In photographic lenses, resolving power is usually determined by examining the image that the lens forms of a series of patterns of dark and light lines of equal widths and known separations. The line separation varies from pattern-to-pattern by a known ratio. In the image, each pattern is characterized by a resolving power value expressed in lines/mm.

The NBS resolving power computations are based on an empirical method with which the resolving power of a lens can be predicted throughout the region of useful imagery provided that reliable values of longitudinal spherical and chromatic aberration are known.<sup>2</sup> In the course of the study it became evident that in most cases the



Plots of NBS data obtained during the investigation of lens resolving power. The resolving power,  $a$ , is given as a function of  $f$ -number ( $b$ ) for several values of  $X$  (relative contrast). These graphs show the reduction of resolving power with increasing chromatic aberration ( $d_c$ ).



These plots show resolving power ( $a$ ) versus  $f$ -number (relative aperture) with  $d_c$  (longitudinal chromatic aberration) value of 0.0 for several values of  $X$  (relative contrast). The data were calculated from an empirical formula devised at NBS during an investigation of lens resolving power.

chromatic aberration was the prime factor in the reduction of resolving power.

For a lens affected only by longitudinal chromatic aberration, Dr. Washer found that the formula

$$X = \frac{d_t}{d_t + d_c} \cdot \frac{a_0^2 - a^2}{a_0^2}$$

gives maximum axial resolving power,  $a$ , in the plane of best imagery at a selected value of the longitudinal chromatic aberration for a series of values of  $X$ . The quantity  $d_t$  is the total depth of focus in the image space throughout which patterns indicating resolving power,  $a$ , are resolved. The quantity  $a_0$  is the maximum theoretical resolving power of the lens.

By using a computer, tables were prepared to give resolving power at selected values of  $X$  for a series of values of  $f$ -number and longitudinal chromatic aberration. Examination of the tabulations leads to a better understanding of the variation of lens performance under differing con-

ditions. They show that when even a small amount of longitudinal chromatic aberration is introduced there is a marked reduction in the attainable maximum resolving power at a given aperture. In addition, when the effect of aperture upon resolving power is considered, the maximum resolving power no longer occurs at maximum stop opening. For example, when  $d_c$  changes from 0.0 to 0.1 mm, the  $f$ -number of maximum resolving power shifts from 2 to 4; as  $d_c$  increases further, the  $f$ -number for maximum resolving power increases also.

By a reversal of the procedure just described, the data obtained in the study may be used to estimate the magnitude of  $d_c$  when the maximum value of resolving power is known for a lens-film combination using film of known characteristics. The method may also be extended to cover changing target contrast.

<sup>1</sup> For further details, see *Effect of chromatic aberration on the resolving power of photographic objectives*, by F. E. Washer, *J. Opt. Soc. Am.* 57, 625 (May 1967).

<sup>2</sup> F. E. Washer, *Photogrammetric Eng.* 32, 213 (1966).

## RESEARCH ASSOCIATE COMPLETES ASSIGNMENT

■ NBS officials have announced the completion of a most significant and productive assignment in the Bureau's Research Associate Program. For six months Alton J. Mabis, a research chemist with the Procter & Gamble Co., worked at the NBS laboratories in Gaithersburg, Md., where he made significant contributions in the field of crystal chemistry.

The experimental work undertaken by Dr. Mabis included investigation and extension of methods for growing highly pure crystals of triglycerides—a group of chemicals important in the food industry. Crystal growth is a method of purification and, when a series of purification steps has been taken, large perfect crystals can be obtained. Such pure crystalline materials have numerous applications in the chemical and pharmaceutical industries, as well as in basic research where they can be used to obtain

knowledge of the relationship between structure, composition and purity, and important physical properties.

Dr. Mabis' work has involved the development of techniques for growing crystals of a special class of high-molecular-weight organic compounds. The techniques, however, have broad application to other classes of compounds of interest to NBS and industry at large. For example, some organic crystals have semiconductive properties and could be of great importance to future technological developments in transistors and other solid state devices. To date, little industrial application of the semiconducting properties of pure organic crystals has been made because knowledge concerning them is limited. Research like that undertaken by Dr. Mabis will increase our knowledge in this area and speed the development of practical applications.

The NBS Research Associate Program is an important means of Government-industry cooperation. Research Associates, supported by their companies, work at NBS laboratories with NBS people on problems of mutual interest. The cooperation multiplies the resources available for the task. Both partners benefit from the research results and personnel development. There are now 56 Research Associates, representing 20 sponsors, doing work in such varied fields as cryogenics, dental materials, fire research, and the development of improved testing procedures for construction materials.

Dr. Mabis left NBS to return to his work and family in Cincinnati, Ohio. At the Procter & Gamble Miami Valley Laboratories in Cincinnati, he assumed the duties of Head of the Diffraction and Radiochemistry Section, Research Division.

# IMPROVED APPARATUS FOR FLASH PHOTOLYSIS STUDIES

Flash photolysis, with time-resolved absorption spectroscopy, is widely used as a method of studying chemical reactions. In these studies, reactions take place as the result of the action of light in producing atoms and radicals. Spectroscopic recordings of the specimens' absorption characteristics give valuable information on the kinetics of reactions of these short-lived species.

Recently, W. Braun, A. M. Bass, and A. E. Ledford, Jr., of the NBS Institute for Basic Standards, devised an improved apparatus for vacuum ultraviolet flash photolysis studies.<sup>1</sup> In this work, which was supported in part by the National Aeronautics and Space Administration, the light available for excitation has been increased. In addition, the new design allows more uniform irradiation of the specimen gas.

Previous systems used at the Bureau<sup>2</sup> and elsewhere for performing vacuum ultraviolet flash photolysis studies generally consisted of a reaction cell that contained the specimen gas, and a flash chamber containing several electrode pairs. The electrode pairs were mounted perpendicular to the reaction vessel and provided radiation which passed through windows into the reaction cell from one side only.

In the Bureau's improved apparatus, the photon flux into the reaction cell has been increased by providing additional electrode pairs, each of which is situated parallel to one of the six faces of a hexagonal reaction vessel. This arrangement has the advantage of permitting the use of larger electrode spacing, thus increasing the light output for each electrode pair. The specimen gas is also irradiated more uniformly because the light enters from all sides of the vessel.

The reaction vessel is a 20.3 cm long piece of hexagonal quartz tubing. Each side of the hexagonal tube has seven equispaced circular lithium fluoride windows that transmit electromagnetic radiation down to 1050 Å (ultraviolet). The window seals, made with an epoxy resin, are strong enough to resist shattering, and are vacuum tight.

The reaction vessel is surrounded by the flash chamber (30.5 cm outside diameter by 22.8 cm long) containing six symmetrically placed electrode pairs. Surrounding the flash chamber is a copper cylinder and an outer frame on which six 10-μF, 10-kV rapid discharge capacitors are mounted. A high voltage connector provides an electrical path from the capacitors to the electrodes. The electrodes are grounded by connection to the copper cylinder which provides a return in the electrical circuit.

A trigger pin in each pair of electrodes is connected by a high-voltage delay cable to one side of a spark gap. The other side of the spark gap is connected to the high-voltage lead of an additional 1-μF, 20-kV capacitor. This capacitor is charged negatively to about 15 kV. When the capacitor voltage exceeds the breakdown potential of the spark gap, a high-voltage pulse is delivered simultaneously to the six delay cables. The pulse, after a constant short delay of about 2 μsec, is transmitted at the same time to each of the six trigger pins. The pulse provides the additional voltage required to initiate the main discharge.

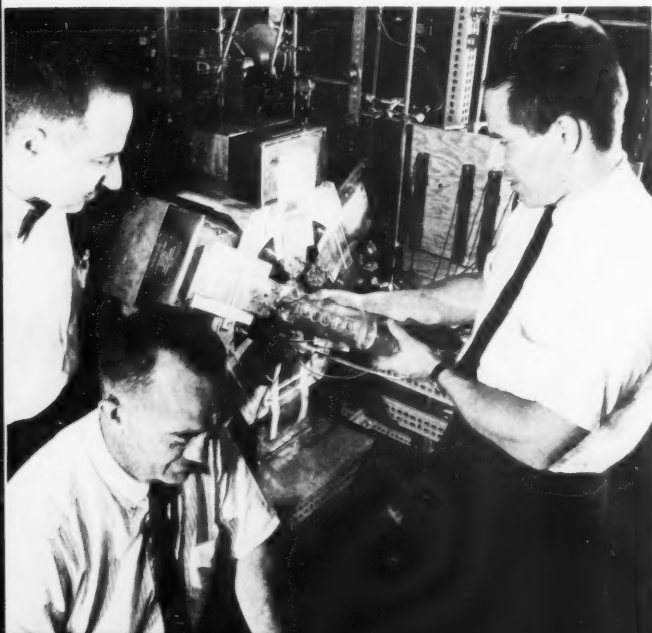
In operation, the flash chamber is filled with nitrogen to a pressure that will inhibit capacitor discharge until the desired voltage is reached. To obtain synchronous firing the flash chamber must be filled at a pressure close to, but slightly higher than, the breakdown pressure.

<sup>1</sup> For further details, see A vacuum ultraviolet flash photolysis apparatus, by W. Braun, A. M. Bass, and A. E. Ledford, Appl. Opt. 6, 47 (Jan. 1967).

<sup>2</sup> Flash photolysis of methane in the vacuum ultraviolet. II. Absolute rate constants for the reaction of CH with CH<sub>4</sub>, H<sub>2</sub>, and N<sub>2</sub>, by W. Braun, J. R. McNesby, and A. M. Bass, J. Chem. Phys. 46, 2071 (1967).

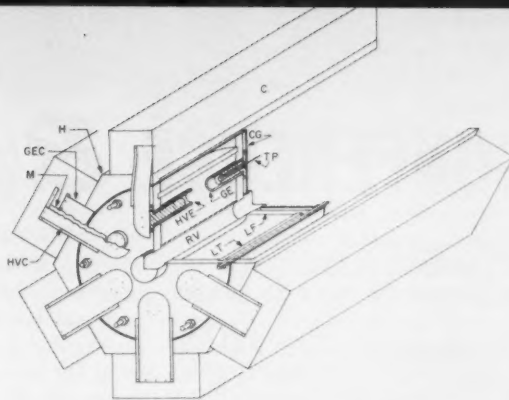
*James R. McNesby inspects data (foreground), while A. M. Bass (left) and W. Braun (right) check the placement of the reaction vessel in the improved flash photolysis apparatus.*

NBS Technical News Bulletin





Isometric drawing of the flash photolysis apparatus: C, capacitor; HVE, high-voltage electrode; GE, ground electrode; HVC, high-voltage connection; GEC, ground-electrode connection; CG, copper can (ground connection); M, insulation; H, hexagonal plate; RV, hexagonal reaction vessel; LT, plastic tube; LF, flange; and TP, trigger pin.



## THEORY EXPLAINS THE "CN LASER"

■ A long-wavelength laser emission from carbon-nitrogen compounds, referred to as the "CN laser," was first reported in 1964.<sup>1</sup> It now provides the most powerful known source of radiation in the far infrared region of the electromagnetic spectrum. Commercial models of this laser are already on the market and have been used for such applications as plasma diagnostics, measurement of optical properties of solids and liquids, and communications experiments. Very recently, the absolute frequency of the laser output has been accurately measured, suggesting the possibility of a new method for determining the speed of light.<sup>2</sup> In spite of the intensive work on this laser in several laboratories, however, the principles of its operation have not been understood.

A number of attempts have been made to explain the laser action as due to CN, a transient free radical which is present in the plasma tube of the laser; the name "CN laser" has thus been attached to the device. However, research at the NBS Institute for Basic Standards has now shown conclusively that HCN (hydrogen cyanide), rather than CN, is responsible for the laser emission. A theory has been developed by A. G. Maki and D. R. Lide, Jr., which explains the major characteristics of the laser in a very satisfactory manner.<sup>3</sup>

The NBS work has shown that HCN molecules are found in the plasma tube in certain highly excited vibrational levels. As a result of a rather special interaction between their vibrational and rotational motions, these molecules undergo a transition to other levels of slightly lower energy which are not significantly populated. In

doing so, each molecule emits a quantum of far-infrared energy, which produces the laser action.

On the basis of this theory, it is now possible to design experiments for improving the performance of the CN—or more properly, HCN—laser. This could only be done on a chance basis before the principles of this laser were understood.

The successful explanation of the HCN laser was made possible by previous NBS measurements on the absorption spectrum of HCN.<sup>4</sup> These very accurate measurements, along with detailed analysis of the energy levels of the HCN molecule, have been carried out over a period of many years as a part of the research program of the Bureau's Infrared and Microwave Spectroscopy Section. This program has led to a thorough understanding of the energy levels and vibrational motions of the HCN molecule. Thus the key information was available when needed to work out the theory of the laser operation. The complexity of the energy levels is such that it would be prohibitive to do a limited set of measurements just for the purpose of understanding the laser; knowledge of the complete pattern of levels was essential before a start could be made on the laser problem.

The measurements on the infrared spectrum of HCN were begun at NBS before the invention of lasers, so that the present application of the results was totally unanticipated. This work thus illustrates the unexpected benefits that often result from a carefully conceived and executed program of basic research.

<sup>1</sup> A stimulated emission source at 0.34 millimetre wave-length, by H. A. Gebbie, N. W. B. Stone, and F. D. Findlay, *Nature* **202**, 685 (1964).

<sup>2</sup> Absolute frequency measurement and spectroscopy of gas laser transitions in the far infrared, by L. O. Hocker, A. Javan, D. R. Rao, L. Frenkel, and T. Sullivan, *Appl. Phys. Letters* **10**, 147 (1967).

<sup>3</sup> On the explanation of the so-called CN laser, by D. R. Lide, Jr., and A. G. Maki, *Appl. Phys. Letters*, to be published.

<sup>4</sup> Infrared spectra of HCN from 2000 to 3600 cm<sup>-1</sup>, by A. G. Maki and L. R. Blaine, *J. Mol. Spectry*, **12**, 45 (1964); Infrared spectra of hydrogen cyanide and deuterium cyanide, by H. C. Allen, Jr., E. D. Tidwell, and E. K. Plyler, *J. Chem. Phys.* **25**, 302 (1956).

# CONFERENCE *Briefs*

## THERMAL CONDUCTIVITY CONFERENCE TO MEET AT BUREAU

On November 13 to 15 NBS will host the Seventh Conference on Thermal Conductivity at its new facilities in Gaithersburg, Md. This Conference is expected to provide a well-rounded discussion of the major areas of thermal conductivity. Papers contributed both from this country and abroad will cover a large volume of new material of general interest.

Participants will discuss such topics as new and improved experimental techniques in the field and methods of measuring thermal conductivity.

Progress in these areas is especially important for studying extremely high and low temperatures, as those encountered in the re-entry of missiles. The program also will include a survey of the developments in the theory of heat conduction; papers on heat conduction in the gas, liquid, and solid states; and new data on potential standard reference materials.

## SYMPOSIUM ON MASS TRANSPORT IN OXIDES

NBS and the Advanced Research Projects Agency will sponsor a Symposium on Mass Transport in Oxides at the Bureau site in Gaithersburg,

Md., from October 22 through 25. Invited papers will include such topics as: (1) a review of mass transport in model systems; (2) theory of energetics of simple defects in oxides; (3) diffusion and ionic conductivity: (a) kinetics of defect motion, (b) interdiffusion and chemical effects; (4) diffusion in oxides; and (5) purity and perfection of research specimens of oxides. Proceedings of the Symposium will be published by the National Bureau of Standards and copies may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.



## STANDARDS AND CALIBRATION

### ATTENUATION CALIBRATION SERVICE IN WR430 WAVEGUIDE (1.70-2.60 GHz)

The NBS Radio Standards Laboratory at Boulder, Colo., announces an extension of microwave attenuation calibration service to include WR430 waveguide (1.70-2.60 GHz). The service includes attenuation difference measurements on variable attenuators and insertion loss measurement on two-port fixed attenuators. Although calibrations can be performed throughout the recommended frequency range of WR430 waveguide, some degree of economy to the customer often results if calibrations are performed at the selected frequencies of 1.8, 2.2, and 2.5 GHz.<sup>1</sup>

The present calibration service can perform attenuation-difference and insertion-loss measurements to a maximum value of 40 dB. The maximum value of attenuation measurement will be increased when further developments have been completed.

The calibration limits of uncertainty will be reported as  $\pm 0.1$  dB or  $\pm 1$  percent of attenuation difference in decibels, whichever is greater for variable waveguide attenu-

ators, and  $\pm 0.2$  dB or  $\pm 1$  percent of insertion loss in decibels, whichever is greater for fixed waveguide attenuators.

Variable waveguide attenuators submitted for calibration should have a repeatability of the dial setting better than  $\pm 0.1$  dB. Both variable and fixed waveguide attenuators submitted for calibration should have a VSWR less than 1.1 at each waveguide port.

### STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz

WWVH—2.5, 5.0, 10.0, and 15.0 MHz

WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment*

made on 1 November 1967. The pulses occur at intervals that are longer than one second by 300 parts in  $10^{10}$  due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on 1 November 1967.*

### WWVH RADIATION PATTERN MODIFIED

In order to improve reception in the Pacific and Far East of signals from standard-frequency station WWVH at Maui, Hawaii, the radiation patterns at 5, 10, and 15 MHz have been modified by installing parasitic reflectors on the existing antennas. The change required several days and was completed at 1500 hours Hawaiian Standard Time on July 20, 1967. (No change has been made on the 2.5-MHz radiation pattern which remains omnidirectional.) WWVH is operated by the National Bureau of Standards.

The design and locations of the reflectors are such as to transmit a maximum of radiation in the direction of Manila with an effective gain of approximately 3 dB, and to give no degradation of the radiation intensities in the directions of Alaska and New Zealand. However, there has been a decrease of about 6 dB in the direction of the main continental portion of the United States of America.

### UTC CLOCK COORDINATION

For the past several months comparisons of the coordinated universal time (UTC) clocks at the U.S. Naval Observatory (USNO) and at NBS (presently known as NBS-UA) have shown a systematic offset in rate of approximately 1.3 parts in  $10^{12}$ . With the intention to improve the synchronization of these two clocks and to maintain their synchronization, the NBS clock was advanced 200 microseconds at 0000 UT on 20 September 1967. Consequently, the phases of the time signals from NBS stations WWV, WWVH, and WWVL were advanced 200 microseconds at the same time. The effect of this reset in epoch was to make the transmitted epochs of time signals from these NBS stations about 30 microseconds early relative to the UTC clock at USNO on the date of adjustment. Because of the offset in rates, the indicated times of the UTC clocks of the two agencies will gradually approach each other. Coincidence in epoch is expected around the middle of 1968, at which time appropriate steps will be taken to ensure continued close agreement.

Following the reset in epoch the NBS clock controlling the time signals emitted from these stations will be referred to as UTC(NBS). Similarly, the corresponding clock at the Naval Observatory will be designated UTC(USNO).

<sup>1</sup> In performing microwave calibrations, a considerable amount of time usually is needed to prepare the system for measurement operation. Much of this preparation is related to adjustment of the system to the frequency of operations selected for the calibration. Time and cost often can be reduced by minimizing the number of times the operating frequency of the calibration system must be readjusted.

## NBS NAMES DEPUTY FOR COMPUTER CENTER

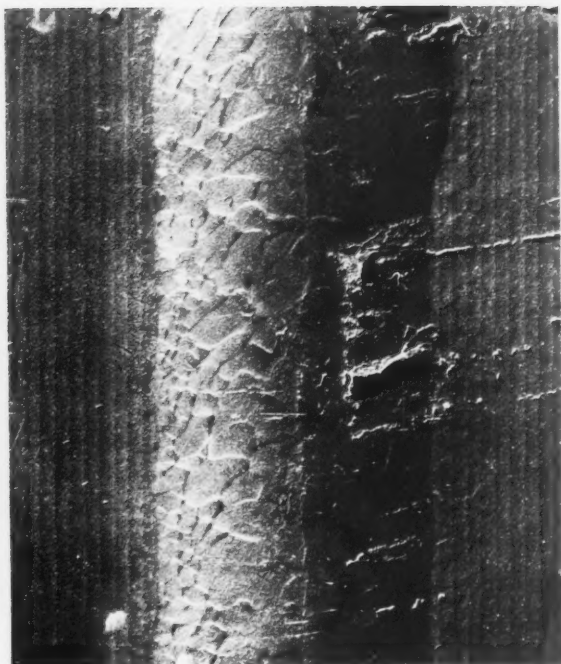
■ William C. Bieber has been named Deputy Director of the Center for Computer Sciences and Technology of the National Bureau of Standards.

The Center develops standards for automatic data processing, conducts research, and provides technical services to other agencies for improving the cost effectiveness of Federal Government programs in the selection, acquisition, and use of automatic data processing equipment.

Mr. Bieber comes to NBS from the Westinghouse

Electric Company where he managed a staff organization providing specialized automatic data processing services. Before joining Westinghouse, he was employed by the General Electric Company where he directed technical activities associated with the sale and installation of computer hardware and software systems to agencies of the Federal Government. Mr. Bieber also spent ten years with the International Business Machines Corporation managing a variety of data processing activities, including a series of contracts for the U.S. Air Force.





*Comparison of a direct photograph (left) and a replica (right) of a titanium weld faithfully reveals identifying features. Note that the replica is a mirror image. Magnifications are approximately X5. Precise identification is still possible at magnifications up to X500.*

## TECHNIQUE "FINGERPRINTS" MISSILES AND OTHER METAL OBJECTS

■ The Bureau has devised a simple but foolproof way to "fingerprint" missiles and other metal objects. This fingerprint will aid in keeping track of items in an arsenal, as would need to be done in checking compliance with an international disarmament or arms control agreement. Developed by T. A. Welsko, D. B. Ballard, and M. R. Meyerson of the Bureau's Institute for Materials Research, the method employs conventional metallographic techniques. The project was initiated at the request of the U.S. Arms Control and Disarmament Agency.

The "fingerprint" used is the metallic microstructure. Its identifying characteristics are the inherent and unique characteristics of the microstructure—grain size and shape, phase distribution, inclusions, and so on. And, like a fingerprint, it can neither

change with time nor be intentionally duplicated.

Two types of identification tags were devised. The first type uses the microstructure as metallographically prepared directly on the surface of the missile. As a result, normal laboratory techniques had to be modified for use in the storage area. The most suitable and least time-consuming means of preparing (grinding, polishing, and etching) the surface area was by the electrolytic method, although mechanical and chemical methods were satisfactory.

The second type of identification tag is the microstructure as metallographically prepared on the surface of a metal label which is later attached to the missile. The configuration of the label—several rods welded into a bar and sliced crosswise—together with the surface characteristics

of the bar, the composition of the rods and weld metal, and the microstructure, are sufficient for identification; however, it may be desirable to stamp serial numbers on the tag for quicker identification. The closed portion of any of the serial numbers, as the number "6" for example, could define the location of the fingerprint area and simplify its relocation.

After the tags have been suitably prepared and their location on the missile noted, the fingerprint area must be recorded accurately for purposes of arms inspection. Either a high-magnification photograph or a replication of the surface area is satisfactory as a means of reidentification of materials. The identification is made by comparing the original photograph or replica with another photograph or replica made of the same area at a later date.

The replication technique is essentially the same process as is used in making phonograph records, coins,

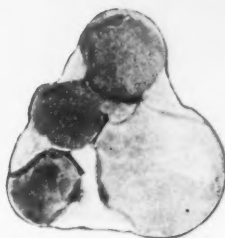
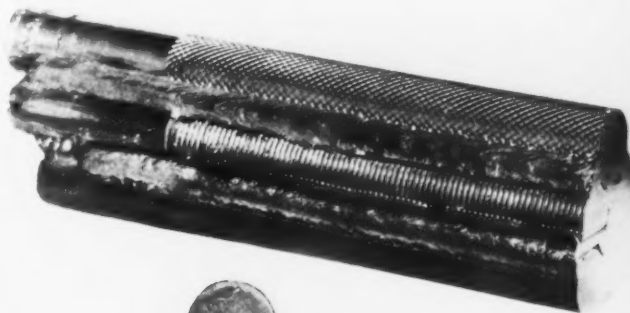
and die castings. The replica is a duplication of the original surface and can reveal faithfully even fine microstructural features. Only a minimum of time (about 1 hour) and materials (principally a solvent and cellulose tape) are required to produce a replica. The tape, softened by the solvent, is pressed against the surface and allowed to harden. After removal to the laboratory, a metal film is vaporized onto the translucent replica to reveal surface details. The replica then can be stored and used to identify a missile at any later time. With this technique, inspections can be made quickly and easily in areas that otherwise would be inaccessible or difficult to check.

The techniques developed are relatively simple. Nonscientists can be taught the required skills for applying and interpreting identification tags after only a brief training period. Satisfactory replicas can be produced after a few hours instruction.



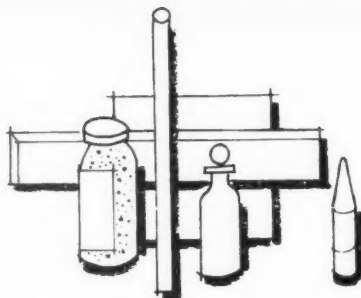
*The translucent replica is being positioned in a metal evaporator by D. B. Ballard. Above the replica is a coiled wire filament containing a small strip of aluminum metal. After the bell jar is lowered and evacuated, a current is passed through the filament, vaporizing the aluminum and depositing a thin film on the replica.*

*Below: To produce the replica, a small square of cellulose tape, softened by a drop of solvent, is pressed against the surface of the titanium weld (foreground). After hardening, a metal film is vaporized onto the translucent replica to reveal surface details. Right: A transmittable tag is fabricated from a weldment of a variety of metal rods sliced crosswise. The bar assembly above is the weldment; the crosswise slice will be metallographically polished and etched to reveal the microstructure.*





# STANDARD REFERENCE MATERIALS



*Standard Reference Materials are well-characterized materials disseminated by NBS to be used in calibrating and evaluating measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base. These materials are certified for chemical composition or for a particular physical or chemical property. They are used on-site in science and industry for calibrating the instruments and methods used for production and quality control of raw materials, chemicals, metals, ceramics, fuels, and radioactive nuclides in manufacturing processes and in research. This column regularly reports on the issuance of new and renewal Standard Reference Materials and on latest developments in the Standard Reference Materials Program.*

Renewals of light-sensitive paper, and a sodium-22 radioactivity standard have been recently certified. Three lead isotopic compositions are also being made available as new Standard Reference Materials.<sup>1</sup>

## STANDARD LIGHT-SENSITIVE PAPERS

Standard light-sensitive paper and booklets of faded strips of this paper are for use in standardizing the dosage of the radiant energy of commercial carbon-arc lamps. The current set of renewal standards are NBS No. 700b, light-sensitive paper, and No. 701b, faded strip booklet. NBS No. 700b, which costs \$25 per unit, consists of 100 strips of paper  $2\frac{5}{8}$  by  $3\frac{1}{4}$  inches. NBS No. 701b, costing \$110, is a booklet of six strips of paper about 3 by  $1\frac{1}{2}$  inches.

The standards in the 701b booklet have been faded by exposure to the NBS master lamp in amounts corresponding to stated numbers of "standard fading hours" of exposure between 7 and 25.<sup>2</sup> The standards were calibrated by J. P. Shouse and E. Passaglia of the NBS Institute for Materials Research. The paper from which the standards were prepared was made in the Bureau's paper mill under the supervision of D. G. Fletcher and was dyed with the direct azo dye, Benzo Azurine G, Color Index No. 24140.

The use of the light-sensitive paper standard is in-

tended to correct for moderate variations in radiant flux. Given the same electrical operating conditions, and similar carbons, the radiant flux emitted by the carbon-arc fading lamp is assumed to be reasonably well controlled with respect to spectral distribution. By using NBS Standard Nos. 700b and 701b it is possible to translate clock hours of exposure in lamps to "standard fading hours" (SFH) based on the average results of 130 exposure tests using different carbon-arc lamps. Thus it is possible to express the dosage of radiant energy on a common basis in different laboratories.

Commercial carbon-arc lamps such as those used for testing textiles for colorfastness to light vary in radiant output from one another and from time to time. Such variations in performance must be considered when using these devices. The standard fading papers and faded strips may be used to check lamp performance to predict the exposure time required to produce fading that corresponds to a specified number of SFH.

In testing textiles for colorfastness to light, many factors affect the reproducibility of results and make such tests difficult to repeat since the fading rate of the paper is sensitive to temperature and humidity. For this reason, the experimental conditions set forth in the Technical Manual of the American Association of Textile Chemists and Colorists, Standard Test Method 16A-1964, must be followed closely. A set of instructions<sup>3</sup> for using the standards and a certificate are supplied with each order for standard faded strips (No. 701b) or paper (No. 700b).

The booklets of standard faded strips and the fading curve supplied with any one issue of unexposed paper apply to that issue only; booklets and unexposed paper of the same issue must be used together. Previous issues of light-sensitive paper Nos. 700 or 700a cannot be interchanged and used successfully with the new booklets 701b. It is not necessary, however, to purchase a new faded strip booklet No. 701b each time No. 700b fading strips are ordered.

The light-sensitive papers are designed primarily for visual estimation. A curve and table of CIE tristimulus luminous reflectance factor Y, as measured on a cali-

bated Gardner-Type Hunter color and color difference meter, against SFH, is supplied with the certificate for information but not as a certified value.

## SODIUM-22 RADIOACTIVITY STANDARD RENEWAL

A sodium-22 gamma-ray solution standard has been certified, and is available for purchase as NBS No. 4922E. The standard, weighing approximately 5 grams, is contained in a flame-sealed glass ampoule and is sold for \$62. A certificate which provides pertinent information is supplied with the standard. NBS 4922E was prepared and calibrated at the NBS Institute for Basic Standards, Radiation Physics Division, by members of the Radioactivity Section under the direction of W. B. Mann.

Sodium-22 is one of the few long-lived positron emitters. It has a high relative positron intensity (90 percent) and a half-life of 2.6 years. The photon energies in the decay of sodium-22 are 1.277 and 0.511 MeV with intensities of 100 and 180 percent, respectively.

The sodium-22 standard is used for calibrating gamma-ray spectrometers. Sodium-22 is a radionuclide used in measurements of the rate of removal of locally injected radiosodium in studies on peripheral circulation; in clinical tracer work to ascertain whether there is long-term retention of sodium in slowly metabolizing tissues; and in research on utilization of nutrient elements taken up by plants through leaves, bark, and fruit. A practical value of the latter application, which has assumed considerable economic importance, is non-root feeding of plants.

This standard may be used for calibrating detectors and detector-spectrometer systems used to measure and detect sodium-22. It fills the continuing need for a standard for workers engaged in positron annihilation and nuclear reaction studies, in plant biology and ecological studies, and in clinical research and diagnosis. The sodium-22 standard is important in the accurate assessment of fission-product distribution in the environment. Sodium-22 has also been used to calibrate gamma-ray pair spectrometers utilized in low count-rate measurements of meteorites.

NBS No. 4922E consists of sodium-22 and carrier in  $5.139 \pm 0.006$  grams of solution. The carrier contains 1.01 grams of sodium chloride per liter of 1N hydrochloric acid. The standard was prepared using the NBS calibrated  $4\pi\gamma$  ionization chamber. The gamma-ray spectrum was examined using a lithium-drifted germanium detector and no radioactive impurities were found.

## ISOTOPIC STANDARDS FOR LEAD

Lead isotopic measurements are used in measuring the ages of rocks, of meteorites, of the earth, and of mineral deposits of great economic importance. Knowledge of the relationship of meteorites to the earth and of

the geologic origins of mineral deposits, can be gained by the measurement of isotope ratios with accurate mass-spectrometric techniques. To advance the knowledge of the nature of geological processes such as volcanic action, mountain formation, ore deposition, and the chemical composition of the earth's interior, accurate comparison of data from different laboratories is necessary. This requires standards for calibrating mass spectrometers, now used extensively in this important work, so that lead-isotope data can be compared on an absolute basis.

Three new lead isotope reference standards, designated NBS Nos. 981, 982, and 983, have been prepared in the NBS Analytical Chemistry Division, Analytical Mass Spectrometry Section under the direction of W. R. Shields as part of the Section's program of absolute isotopic ratio measurements and atomic weight determinations. These standards are sold in a set of three for \$100 and a certificate of isotopic composition is included in the set. Each standard weighs 1 gram. NBS Standard Reference Material No. 981 was prepared from a natural sample of galena (PbS). The No. 983 standard was prepared from radiogenic lead. The No. 982 standard was prepared by mixing normal and radiogenic materials in the proper proportion to give a lead-206/lead-208 ratio of 1. Absolute abundance ratios of the three standard reference materials are as follows:

Absolute Abundance Ratio	NBS-SRM No.		
	981	982	983
Pb-204/Pb-206	0.05904	0.02721	0.000372
Pb-207/Pb-206	.9146	.4669	.07119
Pb-208/Pb-206	2.1678	1.0000	.01362

The starting materials were purified to 99.9+ percent purity and extruded into wire form. Ratio measurements were made by triple-filament mass spectrometry<sup>1</sup> by E. J. Catanzaro, and corrected by comparison with measurements made on mixtures of known compositions prepared from high-purity separated isotopes of lead.

The new standard reference materials will allow laboratories to calibrate instruments over the range of isotopic compositions encountered in nature, and to study the performance of their instruments. They should be useful as "spiking" additions for determining lead, as well as for calibrating mass spectrometers.

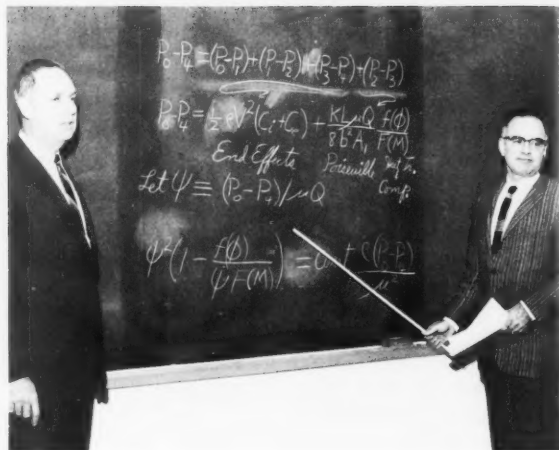
<sup>1</sup> For a complete list of Standard Reference Materials available from NBS, see Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards, NBS Misc. Publ. 260, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which up-date Misc. Publ. 260 are supplied to users on request.

<sup>2</sup> These standards may be purchased for the price indicated from the Office of Standard Reference Materials, National Bureau of Standards, Washington, D.C. 20234.

<sup>3</sup> These instructions are contained in Recommended Method of Use of Standard Light-Sensitive Paper for Calibrating Carbon Arcs Used in Testing Textiles for Colorfastness to Light, NBS Misc. Publ. 260-15, for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 20 cents.

<sup>4</sup> Triple-filament method for solid-sample lead isotope analysis, by E. J. Catanzaro, J. Geophys. Res. 72, 1325-7 (1967).

# NBS EXAMINES LAMINAR FLOWMETER PERFORMANCE



F. W. Ruegg and H. H. Allion review their analysis of laminar flowmeter performance.

Accurate determination of gas flow presents a difficult problem for experimentalists. It requires accurate measurements which give the state of the gas, and which indicate how the state change in the meter influences its performance. For practical reasons this knowledge must be derived from a limited number of measurements intended to cover the range of interest, and from application of an adequate flow theory. In some instances lack of knowledge of gas properties, and extraneous effects of unsteady flow, heat transfer, leaks, gas contamination, and the like can cause difficulty.

In a study at the NBS Institute for Basic Standards an equation was derived by F. W. Ruegg and H. H. Allion<sup>1</sup> that simplifies this measurement problem using laminar flowmeters and should improve techniques for their calibration and use. For accurate use, it was previously necessary to calibrate a flowmeter separately for each gas or different condition of flow. However, using the results derived at the Bureau, the initial calibration is more reliably extended to other gases and flow conditions. The analysis and results should be of value in the design of laminar flowmeters.

The laminar flowmeter has several other common names—linear meter, linear resistance meter, capillary meter, and viscous flowmeter. These names reflect the response characteristics and flow regime observed with laminar flow. The primary element of a laminar flowmeter consists of one or more very shallow, wide slots in metal through which the gas flows. For very low flow rates, a single metering slot is used. At somewhat higher rates, the slots may be formed from an array of concentric cylinders in which the gas flows through the annular spaces. For the higher ranges, the array of slots is formed by wrapping alternate layers of a flat sheet and a crimped or pleated sheet of metal foil into a matrix.

When the slots are properly designed, depending upon the flow range and the characteristics of the gas, there will be laminar flow in each slot. This occurs when the Reynolds number for the slot is kept sufficiently small. When this criterion is met and the flow is incompressible, the pressure drop along the slot, except for end effects, is proportional to the volumetric rate of flow and the fluid viscosity. This may be stated in a modification of the 125-year-old

Hagen-Poiseuille law as  $\Delta P = b\mu Q$ , where  $\Delta P$  is the pressure loss due to the laminar friction,  $\mu$  is the absolute viscosity,  $Q$  is the volumetric flow rate, and  $b$  is a calibration constant.

The above equation may be considered adequate for an incompressible fluid; however, gas is compressible and the formulation of a workable theory is made more difficult when the range of conditions and the meter design require that such similarity parameters as the Prandtl number, the Mach number, the ratio of specific heats, and the Reynolds number be included in the theory. If certain of these parameters can be shown to have little or no effect on meter performance, then a simplified theory would suffice. Frequently, a meter will be used at substantially one pressure and temperature, and with only one gas. Then, depending upon the accuracy desired and the meter used, these simplifications may be justified. However, it is often necessary to make precise flow measurements on a gas or to use one meter calibration for a number of gases.

In the study, using information in the literature, flow through a single-slot laminar flowmeter was analyzed to derive an equation that would ap-

ply to a meter having one slot, and suggestions on how to treat data for meters having many slots. Some approximations were necessary to derive an equation that would take into account the effects on meter performance of gas properties, including compressibility, and of meter design, heat transfer, and slip flow if this is encountered.

The influence of compressible flow and heat transfer was derived using a one-dimensional analysis of the flow of a perfect gas. Coefficients were used in the one-dimensional analysis

to make the results applicable to the actual flow pattern which is considered, for all practical purposes, to be two dimensional. The description of the flow given by Hagen and Poiseuille, with volume rate proportional to pressure differential, was corrected by factors containing the appropriate similarity parameters. The resulting meter equation is given in a form that utilizes measured quantities directly to determine the flow coefficient and the corresponding rate of flow.

To test the equation experimentally, measurements were made in two

single-slot laminar flowmeters using both air and helium as the metered fluid over a wide range of flow and pressure levels. One meter performed in a way similar to that of a multi-slot meter. The curves based on the equation were found to correlate the data accurately for both gases and both meters over the complete range of conditions studied.

<sup>1</sup> An examination of the effects of heat transfer and compressible flow on the performance of laminar flowmeters, by F. W. Ruegg and H. H. Allion, Proc. Flow Measurement Conf. (Am. Soc. Mech. Eng., Fluid Meters Golden Anniversary, Pittsburgh, Pa., Sept. 26-28, 1966), pp. 253-273, 1966.

## ASTIN AND JENSEN RECEIVE UNIQUE PLAQUES

■ In what is believed to be a "first," two Commendation Plaques signed by all fifty of the Governors of the fifty states of the Union, have been presented to two U.S. Department of Commerce officials. The plaques were given to Dr. A. V. Astin, Director of the National Bureau of Standards, and to Mr. Malcolm W. Jensen, Chief of the NBS Office of Weights and Measures.

The unique tribute commemorates the "true spirit of cooperation between Federal, State Governments and Industry officials" represented by the National Conference on Weights and Measures, which meets annually under the leadership of the National Bureau of Standards.

The presentation was made by a two-man committee representing the National Conference on Weights and Measures: Commissioner Lawrence Barker of West Virginia's Department of Labor, and Mr. Arthur Sanders, Executive Secretary of the Scale Manufacturers Association, Washington,

D.C. Mr. Barker originated the idea of this unusual tribute and collected the 50 signatures for the plaques.

Both Commissioner Barker and Mr. Sanders praised Dr. Astin and Mr. Jensen for their work with the National Conference on Weights and Measures. "The importance of weights and measures in the daily lives of every American citizen is often taken for granted," Commissioner Barker said. "It is impossible to name anything that man eats, wears, or uses that is not weighed or measured at least once—and often many times—in its manufacture, processing and/or distribution."

Mr. Sanders praised both Dr. Astin

and Mr. Jensen for "outstanding leadership" in making the National Conference on Weights and Measures a "model of Federal, State and local governmental cooperation."

The presentation was made on Friday, August 4, because of Dr. Astin's absence from the United States on official business during the meeting of the National Conference on Weights and Measures in June.

*Malcolm W. Jensen and Allen V. Astin hold plaques presented them by the National Conference on Weights and Measures. (From left) Arthur Sanders, Executive Secretary of the Scale Manufacturers Association; Mr. Jensen; Dr. Astin; and Laurence Barker, Commissioner, West Virginia Department of Labor.*





# IONIZATION CONSTANT OF HEAVY WATER REDETERMINED

■ In 1930 heavy water (deuterium oxide,  $D_2O$ ) was a laboratory curiosity, but today, as it continues to become more readily available, it is finding increasing applications in science and industry. For example, it serves as a moderator and a coolant in nuclear reactors where it is an efficient absorbent for radiation. Deuterium oxide is also employed extensively as a tracer in chemical and biological research; medical tracer techniques make use of it for water volume measurements in the body.

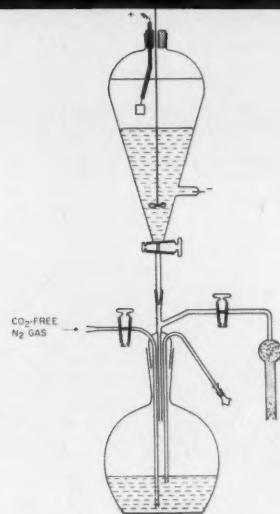
For studying chemical reactions utilizing this solvent, it is important to have accurate values for the ionization constant ( $pK$ ), of heavy water in order to know the relative range and strength of acids and bases dissolved in it. Although the constant has been determined and used effectively in the past, a number of uncertainties exist in the previous values. Recently, more accurate values over the range from 5 to 50 °C have been obtained by R. G. Bates and R. A. Robinson, of the NBS Institute for Materials Research, and A. K. Covington, NBS guest worker from the University of Newcastle upon Tyne, England.<sup>1</sup>

These investigators found that some of the uncertainty in the earlier work arose out of the need to extrapolate to 100 percent  $D_2O$  since a highly pure solution of  $D_2O$  was unavailable at that time. They were able to reduce the error due to extrapolation by using deuterium oxide of higher purity—99.7 percent  $D_2O$ . Other uncertainties, such as confusion over the concentration scales used by different workers, also had to be resolved. Taking these various factors into account, they derived a series of values about 0.15 higher in the negative logarithm of the constant than those previously reported.

To determine values for the ionization constant over the temperature range studied, the electromotive force of a cell was measured employing a stock solution as the electrolyte. The cell, which was free from the uncertainties of a liquid junction, contained a silver-silver chloride electrode, a platinum electrode over which deuterium gas was bubbled, and a solution consisting of NaOD and NaCl in  $D_2O$ .

The solution of NaOD was prepared by a modification of an earlier method<sup>2</sup> whereby a sodium amalgam was produced electrolytically and then decomposed in  $D_2O$ . Electrolysis was carried out in a separatory flask containing distilled mercury and NaOH in  $D_2O$ . At the conclusion of the electrolysis, the amalgam was run into a flask containing  $D_2O$  through which carbon dioxide-free, dry nitrogen gas had been bubbled. The reaction between the sodium amalgam and  $D_2O$  was hastened by maintaining the flask at a temperature of 80 to 90 °C. Then, NaCl in

*In the determination of the ionization constant of heavy water, the NaOD solution for emf measurements was prepared electrolytically in the apparatus shown.*



$D_2O$  was added to this to yield the stock solution from which the cell solutions were prepared.

After the preparation of the cells and electrodes, the cell compartment was filled with the solution and both electrodes were completely immersed in it. The emf was measured over the temperature range and the results corrected to 1 atm partial pressure of deuterium gas.

From the emf measurements, values were derived for the ionization constant on the molal scale, the molarity scale, and the mole fraction scale. A value of 14.869 was obtained for  $pK$  of heavy water on the molarity scale at 25 °C, as compared with a value of 14.000 for ordinary water. The heat of ionization of heavy water at 25 °C was found to be 14,311 cal mol<sup>-1</sup>,\* whereas similar measurements made several years ago gave 13,526 cal mol<sup>-1</sup> for ordinary water.

\*1 cal = 4.1840 joules.

<sup>1</sup> The ionization constant of deuterium oxide from 5 to 50°, by A. K. Covington, R. A. Robinson, and R. G. Bates, *J. Phys. Chem.* 70, 3820 (1966).

<sup>2</sup> The conductance of dilute aqueous sodium hydroxide solutions from 15° to 75°, by K. N. Marsh and R. H. Stokes, *Australian J. Chem.* 17, 740 (1964).

Table 1.

The  $pK$  values for heavy water, as calculated from the NBS data, are compared with the literature values for  $pK$  for ordinary water. Values are shown for the molal scale ( $pK_m$ ), the molarity scale ( $pK_c$ ), and the mole fraction scale ( $pK_N$ ), over the range from 10 to 50 °C.

t, °C	$D_2O$			$H_2O$		
	$pK_m$	$pK_c$	$pK_N$	$pK_m$	$pK_c$	$pK_N$
10	15.526	15.439	17.224	14.535	14.535	16.279
20	15.136	15.049	16.384	14.167	14.169	15.911
25	14.955	14.869	16.653	13.997	14.000	15.741
30	14.784	14.699	16.482	13.833	13.837	15.577
40	14.468	14.385	16.166	13.535	13.542	15.279
50	14.182	14.103	15.880	13.262	13.272	15.006





# NEWS

## Thermophysical Properties Research Center

The Thermophysical Properties Research Center (TPRC), Purdue University, was formally established on January 1, 1957, with the broad mission

To become a world center for research and the collection, analysis, correlation, and dissemination of thermophysical properties information and, as such, to serve education, science, and technology through a better knowledge of this area.

TPRC plans to maintain surveillance of world literature for 16 thermophysical properties for all substances with no limits of pressure, temperature, or physical state. The properties covered are thermal conductivity, accommodation coefficient, thermal contact resistance, thermal diffusivity, specific heat at constant pressure, viscosity, emissivity, reflectivity, absorptivity, transmissivity, solar radiation ratio ( $\alpha/\epsilon$ ), diffusion coefficient, thermal linear expansion, thermal volumetric expansion, surface tension, and Prandtl number.

The overall activities of TPRC are organized into four divisions:

- (1) Scientific Documentation Division
- (2) Data Tables Division
- (3) Experimental Research Division
- (4) Theoretical Research Division

Each area of activity, while distinct in itself, is interrelated with the other three. However, the first two divisions will be discussed in more detail as they are more closely related to TPRC's information and data center activities.

The mission assigned to the Scientific Documentation Division is to be completely informed of all recorded knowledge on the 16 thermophysical properties enumerated above. For the first 13 of these properties the world literature has been systematically searched back to the year 1920 (and in some cases earlier) and has been codified and stored in mechanized form for instant search and retrieval. To assist the individual engineer or scientist in performing his own retrospective literature retrieval, TPRC publishes this information at periodic in-

tervals of approximately every three years as a unique 3-book volume, the *Retrieval Guide*. In late November 1967, the latest and most comprehensive edition<sup>1</sup> will become available covering the world literature on 13 properties for the period 1920 to mid-1964. This publication supersedes two earlier issues.

The basic output of the Data Tables Division is the TPRC Data Book, which consists of loose leaf data sheets released semiannually. The contents of these data sheets provide two types of standard reference data: preliminary and critically evaluated data.

To strengthen its claim of being the best informed center within its area of cognizance, TPRC constantly strives to maintain close working relationship with major centers of research both in this country and abroad. TPRC has established an affiliated branch in Japan (1963) and another in Belgium (1966). These affiliates of TPRC perform two major functions: first, data analysis of specific properties as part of the data tables programs; and secondly, feedback of Far Eastern and European research results not uncovered by TPRC's systematic literature search.

TPRC's experimental research activities closely parallel its efforts on the generation of critical tables of standard reference data. Its laboratory serves in a supporting function to the theoretician or analyst, whose concern is prediction of reliable estimates of property values. The experimental work is directed toward the following basic goals:

- (a) to perform systematic and deliberately selected investigations to resolve serious discord in existing information;
- (b) to fill in those gaps in the data that are necessary for a better understanding of the thermal behavior of materials;
- (c) to make new studies to obtain results that will help to improve our capabilities for the quantitative prediction of the thermophysical properties for a wider range of materials over a wider range of parameters without resorting to routine measurement;
- (d) to generate accurate experimental data to confirm or improve the validity of existing theories or to use them as input information for the development of new theories; and

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(e) to serve as a training ground for graduate students specializing in thermophysics.

TPRC is part of the network of data centers associated with the Office of Standard Reference Data.<sup>2</sup>

### The U.S.S.R. State System of Standard Reference Data (GSSSD)

During the recent meeting of the Committee on Data for Science and Technology of the International Council of Scientific Unions in Moscow, M. A. Styrikovich reported on data compilation activities in the U.S.S.R. and on the establishment of the State System of Standard Reference Data (GSSSD). The GSSSD is a responsibility of the State Committee on Standards, under the general supervision of I. I. Novikov, Deputy Chairman of the State Committee on Standards.

The GSSSD has been in existence for approximately one year, although many data compilation projects were carried on long before the formal program was conceived. Up to now the GSSSD has been in the early stages of planning and organizing its activities.

The scope of the U.S.S.R. program is broader than that of the U.S. National Standard Reference Data System, in that it includes less well-defined properties of complex materials, customarily called "engineering properties," which are at present outside the scope of the U.S. program. In addition, the Soviet program maintains closer relationships with experimental measurement programs than is envisioned in the U.S. program, and plans to centralize much of the data evaluation activities. Eventually a large fraction, if not most, of the evaluation of data taken from the literature is to be carried out within the central office, whereas the U.S. program envisions essentially no data evaluation by the central office (which is for program management and information dissemination).

Approximately one-third of the present staff of the GSSSD central office is concerned with planning and organization, including such problems as the relationships between the various ministries and institutes which are to participate in the program, methods of informing the technical community about the products and services of the GSSSD, and how best to present and transfer the information that is produced within the system. Another third of the staff addresses itself to problems of criteria for evaluating data, development of methods of making calculations, evaluating measurement methodology, and deciding which properties of which substances are to be measured in the experimental program. The remaining third of the staff is concerned with machine methods of processing data, including study of the problems of classifying data, file organization, and techniques for storing and retrieving information.

Approximately 100 titles are now in preparation in various institutes and laboratories throughout the Soviet

Union. These works are concerned with data evaluation, critical reviews, state-of-the-art reviews, and measurement methodology. The technical areas receiving most emphasis are thermodynamics and transport properties and chemical kinetics. Most of the 100 works in preparation are to appear by 1970. One of the major projects is a multi-volume work containing a complete review of the quantitative data on the kinetics of chemical reactions; this is to appear in three parts: gas phase reactions, liquid phase reactions, and solid phase reactions. The International Steam Tables Project and the IUPAC Project on Industrially Important Gases have stimulated major projects for experimental measurement and data evaluation. Another major effort within the Soviet Union is concerned with refining the values of the fundamental physical constants. Plans have been made to establish a national nuclear data center in the near future, and a geophysical data center is being considered.

### Data Center on Atomic Transition Probabilities

In June 1960, the Data Center on Atomic Transition Probabilities, under the direction of W. L. Wiese, was established in the NBS Atomic Physics Division with the joint support of the Advanced Research Projects Agency and the National Bureau of Standards.

The seven years since the Data Center was established have seen a rapid growth in the field of atomic spectroscopy. This has been caused by urgent needs in areas where basic atomic data are employed, namely, plasma physics, astrophysics, and space research.

The mission of the Data Center is twofold: to collect and catalog all relevant literature, and to extract and critically analyze the numerical data. The first part of the program, the retrospective searching and cataloging of all relevant literature in a complete up-to-date file, was essentially completed in 1962. Since then, the literature has been constantly monitored and bibliographies have been published as the increase in references seemed to warrant. The most recent is "Bibliography on Atomic Transition Probabilities," NBS Miscellaneous Publication No. 278 (55 cents).<sup>3</sup> At present the Center's files contain about 1,000 papers.

After 1962 when the retrospective searching of the literature had been completed, the emphasis was changed to the second and more important aspect of the program—the critical evaluation of the collected numerical data in the literature, and publishing the tables of "best" atomic transition probability values. Since the lightest ten elements (hydrogen through neon) had been of dominant interest to scientists and more data were available on these elements, it was decided to concentrate on them. It was hoped that sufficient and reliable material would be readily available for a fairly comprehensive list, which would contain data for at least all the strong prominent transitions. However, a number of gaps and large discrepancies were found in the material and the theoretical

and experimental efforts of several members of the NBS Plasma Spectroscopy Section were needed to remedy the most critical situations. Through their efforts a more complete critically evaluated data compilation was produced, *Atomic Transition Probabilities—Hydrogen Through Neon*, NSRDS-NBS-4 (\$2.50).<sup>3</sup>

At present, critical evaluation is continuing for the second ten elements (sodium through calcium) and it is hoped this will be published within a year. As was the case with the first ten, a number of gaps and large discrepancies have been found in the literature. Theoretical and experimental work is in progress and hopefully will correct or at least shed some light on these problems.

### Advisory Panel on Atomic and Molecular Properties

The main advisory bodies that provide specialized guidance to the National Standard Reference Data System are now part of the National Academy of Sciences—National Research Council.<sup>4</sup> The Advisory Panel on Atomic and Molecular Properties was the first of these units to meet under the new structural arrangement. Chairman E. U. Condon and the National Academy of Sciences' Office of Critical Tables, as hosts, called the Panel together on May 19 and 20, 1967, to hear reports on the status of the data compilation program on atomic and molecular properties, and to make recommendations about problem areas, relative priorities for projects, and routes to international cooperative efforts.

Further implementation of the general plan of advisory groups came more recently with the calling of the first *ad hoc* subpanel of the Atomic and Molecular Advisory Panel. The subpanel met on July 24 and 25 to consider the application of computers to the measurement, the storage and retrieval of spectral data, and the digitization of spectral information. E. R. Lippincott, Professor of Chemistry at the University of Maryland, chaired the special

sessions. In addition to considering the state-of-the-art in various phases of computer utilization in spectroscopy, the Panel heard reports on several individual efforts to develop multiple-input, computer-based programs for analysis and identification of materials using several types of spectroscopy simultaneously.

No formal report of the *ad hoc* Panel's considerations is planned. However, recommendations and resolutions were made which will give U.S. representatives a basis for their reports on similar topics to the 9th European Congress on Molecular Spectroscopy, which met in Madrid, September 10–15, 1967.

### Two Publications From the Atomic and Molecular Processes Information Center

The Atomic and Molecular Processes Information Center at Oak Ridge National Laboratory has completed and published a *Bibliography of Atomic and Molecular Processes* for January–June 1965.<sup>5</sup> This annotated bibliography contains references of interest to atomic and molecular processes research. Bibliographical sources consisted of 78 scientific journals and 5 abstract journals. The references are classified into 14 major categories with appropriate subcategories. Each alphabetic entry in the respective category includes the reactants or the atomic and molecular system of interest.

The Atomic and Molecular Processes Information Center has also revised the 1965 edition of its *International Directory of Workers in the Field of Atomic and Molecular Collisions*.<sup>5</sup>

<sup>1</sup> Thermophysical Properties Research Literature—A Retrieval Guide, Y. S. Touloukian, Editor, Plenum Press, New York, 1967.

<sup>2</sup> See NSRDS News, Tech. News Bull. 51, No. 8, 177 (Aug. 1967).

<sup>3</sup> Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

<sup>4</sup> See NSRDS News, Tech. News Bull. 51, No. 6, 120 (June 1967).

<sup>5</sup> Available from the Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tennessee 37830.

## PUBLICATIONS of the National Bureau of Standards\*

### PERIODICALS

*Technical News Bulletin*, Volume 51, No. 9, September 1967. 15 cents. Annual subscription: \$1.50. 75 cents additional for foreign mailing. Available on a 1-, 2-, or 3-year subscription basis.

*Journal of Research of the National Bureau of Standards*  
Section A. *Physics and Chemistry*. Issued six times a year. Annual subscription: Domestic, \$5; foreign, \$6. Single copy, \$1.

Section B. *Mathematics and Mathematical Physics*. Issued

quarterly. Annual subscription: Domestic, \$2.25; foreign, \$2.75. Single copy, 75 cents.

Section C. *Engineering and Instrumentation*. Issued quarterly. Annual subscription: Domestic, \$2.75; foreign, \$3.50. Single copy, 75 cents.

### OTHER NBS PUBLICATIONS

Effects of finite lattice heat capacity on spin-lattice relaxation theory and numerical analysis, R. L. Peterson, Mono. 102 (Aug. 1, 1967), 25 cents.

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## PUBLICATIONS *continued*

- Grading of abrasive grain on coated abrasive products, PS8-67 (Jan. 9, 1967), 15 cents. (Supersedes CS217-59).
- Hardboard, CS251-63, reprinted April 1967 with amendments (Nov. 15, 1966), 10 cents.
- NBS standard frequency and time services, radio stations WWV, WWVH, WWVB, WWVL, Misc. Publ. 236, 1967 Edition (1967), 15 cents.
- Nuclear science and technology for ceramists, Proceedings of the American Ceramic Society Symposium, Washington, D.C., April 7-12, 1966, Misc. Publ. 285 (May 26, 1967), \$1.75.
- Proceedings of the 1966 Standards Laboratory Conference, Misc. Publ. 291 (July 13, 1967), \$1.
- Quantum mechanical calculations of the second virial coefficients for hydrogen, M. E. Boyd and S. Y. Larsen, Tech. Note 412 (Apr. 10, 1967), 15 cents.
- Quantitative methods for management, G. Suzuki, Tech. Note 414 (May 23, 1967), 25 cents.
- Standard Reference Materials: Recommended method of use of standard light-sensitive paper for calibrating carbon arcs used in testing textiles for color-fastness to light, E. Passaglia and P. J. Shouse, Misc. Publ. 260-15 (July 21, 1967), 20 cents.
- Thermal radiation property measurement techniques, S. T. Dunn, J. C. Geist, D. G. Moore, H. E. Clark, and J. C. Richmond, Tech. Note 415 (Apr. 27, 1967), 50 cents.

## PUBLICATIONS IN OTHER JOURNALS

*This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.*

### CHEMISTRY

- Calorimetry, G. T. Armstrong, 1967 McGraw-Hill Yearbook of Science and Technology, pp. 124-127 (1967).
- Charge-transfer spectrum of the tetrachlorocuprate ion, M. Sharnoff and C. W. Reimann, J. Chem. Phys. **46**, No. 7, 2634-2640 (Apr. 1, 1967).
- Correlation of some Precambrian rocks and metamorphic events in parts of Wyoming and Montana, E. J. Catanzaro, Mt. Geol. **4**, No. 1, 9-21 (1967).
- Determination of trace elements in standard reference materials by neutron activation analysis, G. W. Smith, D. A. Becker, G. J. Lutz, L. A. Currier, and J. R. DeVoe, Anal. Chim. Acta **38**, 333-340 (1967).
- Distillation as a tool for purification of research quantities of material, R. T. Leslie, Ann. N.Y. Acad. Sci. **137**, 19-29 (1966).
- Erratum: Mass-spectrometric study of the reactions of O atoms with NO and NO<sub>2</sub>, F. S. Klein and J. T. Herron, J. Chem. Phys. **44**, No. 9, 3645-3646 (May 1, 1966).
- Gas phase radiolysis of cyclobutane, R. D. Doepker and P. Ausloos, J. Chem. Phys. **44**, 1641-1647 (Feb. 1966).
- Investigating ion-molecule reactions by analyzing neutral products formed in the radiolysis and photoionization of hydrocarbons, P. Ausloos, S. G. Lias, and A. A. Scala, Adv. Chem. Ser. **58**, 264-277 (1966).
- Magnetic and optical spectra of two dimeric copper-chloride pyridine-N-oxide complexes, G. F. Kokoszka, H. C. Allen, Jr., and G. Gordon, J. Chem. Phys. **46**, No. 8, 3013 (Apr. 1967).
- Mass spectrometric study of the photoionization of small molecules, V. H. Dibeler, R. M. Reese, and M. Krauss (Proc. 3d Intern. Conf. Mass Spectrometry, Paris, France, Sept. 1964), Book, Advances in Mass Spectrometry **3**, 471-488 (Institute of Petroleum, London, England, 1966).
- Measurement of the direct I-doublet transitions in carbonyl sulfide, A. G. Maki, J. Mol. Spectry. **23**, No. 1, 110-111 (May 1967).
- Microtexture and composition of reaction products in the system kaolin-lime-water, W. C. Ormsby and L. A. Bolz, J. Am. Ceram. Soc. **49**, No. 7, 364-366 (July 1966).
- Microwave spectroscopy, D. R. Lide, Jr., Encyclopedia of Industrial Analysis **2**, 600-611 (John Wiley and Sons, Inc., New York N.Y., 1966).
- Microwave spectrum of excited vibrational states of FCN, W. J. Lafferty and D. R. Lide, Jr., J. Mol. Spectry. **23**, No. 1, 94-9 (May 1967).
- Microwave spectrum, structure, dipole moment, and barrier to internal rotation of phosphorus trifluoride-borane, R. L. Kuczkowski and D. R. Lide, Jr., J. Chem. Phys. **46**, No. 1, 357-365 (Jan. 1967).
- Microwave studies of rotational isomerism, D. R. Lide, Jr., Trans. Am. Cryst. Assoc. **2**, 106-116 (1966).
- Monomer-polymer equilibria of deuteriated alpha-methylstyrenes, L. J. Fetters, W. J. Pummer, and L. A. Wall, J. Polymer Sci. **4**, Part A-1, 3003-3011 (1966).
- Mossbauer spectroscopy: Applications to aerospace, J. R. DeVoe and J. J. Spijkerman, Book, Radioisotopes for Aerospace, Part 2, Systems and Applications, pp. 254-269 (Plenum Press, Inc., New York, N.Y., 1966).
- Needs of American Chemical Society members for property data, H. M. Weisman, J. Chem. Doc. **7**, No. 1, 10-14 (Feb. 1967).
- Nuclear magnetic relaxation studies of (CD<sub>3</sub>O)<sub>2</sub>BH, N. Boden, H. S. Gutowsky, J. R. Hansen, and T. C. Farrar, J. Chem. Phys. **46**, No. 7, 2849 (Apr. 1, 1967).
- Photolysis of cyclopentane at 1470, 1236, and 1048-1067 Å, R. D. Doepker, S. G. Lias, and P. Ausloos, J. Chem. Phys. **46**, No. 11, 4340-4346 (June 1, 1967).
- Radiation and photochemistry, P. Ausloos, Ann. Rev. Phys. Chem. **17**, 205-236 (1966).
- Simultaneous determination of copper and zinc in human lung tissue by neutron activation analysis, R. G. Keenan, J. H. Marcus, and J. R. DeVoe, Am. Ind. Hygiene Assoc. J. **27**, 128-134 (Mar.-Apr. 1966).
- Sublimation, E. C. Kuehner and R. T. Leslie, Encyclopedia of Industrial Chemical Analysis **3**, 573-584 (1966).
- Symposium on problems of small information groups. Introductory remarks, M. B. Henderson (Div. Chem. Lit. Symp. Problems of Small Information Groups, 151st Natl. Meeting Am. Chem. Soc., Pittsburgh, Pa., Mar. 25, 1966), J. Chem. Doc. **6**, 143 (Aug. 1966).
- Systematic errors in "recovery" and "detection" efficiency as related to radiochemical analysis, L. A. Currie, Proc. 11th Annual Bio-Assay and Analytical Chemistry Meeting, Albuquerque, N. Mex., Oct. 7-8, 1965, AEC No. 651008, pp. 35 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 1967).
- The chain decomposition of propane initiated by vacuum ultraviolet photolysis, A. H. Laufer and J. R. McNesby, J. Phys. Chem. **70**, 4094-4096 (1966).
- The crystal structure of sodium tetraborate, A. Hyman, A. Perloff, F. Maurer, and S. Block, Acta Cryst. **22**, No. 6, 815-821 (June 1967).
- The microwave spectrum and dipole moment of pyrazole, W. H. Kirchhoff, J. Am. Chem. Soc. **89**, No. 6, 1312-1316 (Mar. 1967).
- The microwave spectrum, structure, dipole moment, and quadrupole coupling constants of trans-nitrous acid, A. P. Cox and R. L. Kuczkowski, J. Am. Chem. Soc. **88**, No. 22, 5071-5074 (Nov. 1966).
- Thermal decomposition of 4,4-dimethylpentene-1 in a single-pulse shock tube, W. Tsang, J. Chem. Phys. **46**, No. 7, 2817-2822 (Apr. 1, 1967).
- Thermal radiation property measurement techniques, S. T. Dunn, J. C. Geist, D. G. Moore, H. E. Clark, and J. C. Richmond, Tech. Note 415 (Apr. 27, 1967), 50 cents.
- Two National Bureau of Standards data centers: Chemical kinetics and mass spectrometry, D. Garvin and H. M. Rosenstock, J. Chem. Doc. **7**, No. 1, 31-34 (Feb. 1967).
- Vacuum-ultraviolet photolysis of solid propane at 20° and 77°K, R. E. Rebbert and P. Ausloos, J. Chem. Phys. **46**, No. 11, 4333-4339 (June 1967).



Vapor deposition of tungsten by hydrogen reduction hexafluoride process variables and properties of the deposit, J. F. Berkeley, A. Brenner, and W. E. Reid, Jr., *J. Electrochem. Soc.* **114**, No. 6, 561-568 (June 1967).

## PHYSICS

Note on thermal expansion coefficients of rare gas solids, R. D. Mountain, *J. Phys. Chem. Solids* **28**, 1071-1073 (Dec. 29, 1966).

A simple and accurate method of calibration by photopeak efficiencies, J. M. R. Hutchinson and D. H. Walker, *Intern. J. Appl. Radiation Isotopes* **18**, No. 1, 86-89 (Jan. 1967).

Additional stopping power and range tables for protons, mesons, and electrons, M. J. Berger and S. M. Seltzer, NASA-SP-3036 (1966).

Alpha-gamma angular correlations in three heavy odd-A nuclides, J. M. R. Hutchinson, *Phys. Rev.* **157**, No. 4, 1093-1098 (May 1967).

An optical power limiter, B. L. Danielson, *Appl. Opt.* **6**, No. 1, 158-159 (Jan. 1967).

Annual report on spectroscopy, C. E. Moore, *Astron. J.* **71**, No. 9, 796-797 (Nov. 1966).

Approximate eigenfunctions of the Liouville operator in classical many-body systems, II. Hydrodynamic variables, R. Nossal and R. Zwanzig, *Phys. Rev.* **157**, No. 1, 120-126 (May 5, 1967).

Autoionizing D states in He below the  $n=2$  level of He<sup>+</sup>, J. W. Cooper, S. Ormonde, C. H. Humphrey, and P. G. Burke, *Proc. Phys. Soc.* **91**, 285-287 (1967).

Autoionization spectra of the noble gases, R. P. Madden and K. Codling (Proc. Symp. Atomic Interactions and Space Physics, Goddard Space Flight Center, Greenbelt, Md., Aug. 10-11, 1965), Book, *Autoionization: Astrophysical, Theoretical, and Laboratory Experimental Aspects*, pp. 129-151 (Mono Book Corp., Baltimore, Md., 1966).

Certificates of radioactivity standards, S. B. Garfinkel, A. P. Baerg, and P. E. Zigman, Report of the Subcommittee on the Use of Radioactivity Standards, Natl. Acad. Sci.-Natl. Res. Council, pp. 1-11 (Washington, D.C., Dec. 1966).

Chromatic changes induced by changes in chromaticity of background of constant lightness, H. Takasaki, *J. Opt. Soc. Am.* **57**, No. 1, 93-96 (Jan. 1967).

Cold-neutron study of hindered rotations in solids and liquid methyl chloroform, neopentane, and ethane, J. J. Rush, *J. Chem. Phys.* **46**, No. 6, 2285-2291 (Mar. 1967).

Comments on "Nature of the critical nucleus in heterogeneous vapor-solid nucleation," A. J. Melmed and S. C. Hardy, *Surface Sci.* **6**, No. 4, 481-482 (April 1967).

Compensation and band tailing effects in high power room temperature GaAs lasers, N. N. Winogradoff and H. K. Kessler, *Solid-State Communications* **5**, 155-158 (Pergamon Press Ltd., London, England, 1967).

Conformation of adsorbed polystyrene measured by attenuated total reflection in the ultraviolet region, P. Peyser and R. R. Stromberg, *J. Phys. Chem.* **71**, No. 7, 2066-2074 (June 1967).

Correction of some erroneous calculations of the Einstein A coefficient for the 18 cm transition of OH, D. R. Lide, Jr., *Nature* **213**, 694-695 (Feb. 18, 1967).

Correlation of spherical aberration of axially symmetrical magnetic lenses, L. Marton, *Rev. Sci. Instr.* **38**, No. 1, 130-131 (Jan. 1967).

Correlation of large longitudinal deformations with different strain histories, L. J. Zapas and T. Craft, *Rubber Chem. Technol.* **40**, No. 2, 506-516 (Mar. 1967).

Deformation twinning in Ni and F.C.C. Fe-Ni alloys, R. P. Reed, *Phil. Mag.* **15**, No. 137, 1051-1055 (May 1967).

Dependence of 50 and 100 keV bremsstrahlung on target thickness, atomic number, and geometric factors, R. C. Placius, *J. Appl. Phys.* **38**, No. 5, 2030-2038 (Apr. 1967).

Development of the engineering method and some simplified methods of structure shielding analysis, C. Eisenhauer (Lecture Notes, OCD Summer Inst., Kansas State Univ., Manhattan, Kans., 1962-1963, 1965), TR-40, Radiation Shielding—Analysis and

Design Principles as Applied to Nuclear Defense Planning, V-i-V-iv (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., Nov. 1966).

Dielectric constants of PbWO<sub>3</sub> and CaWO<sub>3</sub>, W. S. Brower and P. H. Fang, *J. Appl. Phys.* **38**, No. 5, 2391 (Apr. 1967).

Dislocation node determinations of the stacking fault energy in silver-tin alloys, A. W. Ruff, Jr., and L. K. Ives, *Acta Met.* **15**, 189-198 (Feb. 1967).

Effect of oxygen on the photoelectron yield from tungsten in the vacuum ultraviolet, B. J. Wacławski, L. R. Hughey, and R. P. Madden, *Appl. Phys. Letters* **10**, 305 (1967).

Effects of environment on the fracture of glass, S. M. Wiederhorn, Proc. RIAS Conf., Baltimore, Md., June 7-8, 1965, pp. 293-317 (Gordon and Breach, New York, N.Y., 1966).

Eigenchannel theory of nuclear reactions, M. Danos and W. Greiner, *Phys. Rev.* **146**, No. 3, 708-712 (June 1966).

Electron beams: National Bureau of Standards and the new technology, H. W. Koch, *Science* **156**, No. 3773, 321-328 (Apr. 21, 1967).

Electron monochromator design, C. E. Kuyatt and J. A. Simpson, *Rev. Sci. Instr.* **38**, No. 1, 103-111 (Jan. 1967).

Estimate of extrinsic stacking-fault energies from dislocation configurations, W. F. Hartl, R. deWit, and R. E. Howard, *J. Appl. Phys.* **38**, No. 1, 1-4 (Jan. 1967).

Excitation and ionization in arc and spark spectroscopic sources, M. Margoshes, *Appl. Spectry* **21**, No. 2, 92-99 (1967).

Experimental evidence concerning the conduction band of SrTiO<sub>3</sub>, H. P. R. Frederikse, W. R. Hosler, and W. R. Thurber (Proc. Intern. Conf. Physics of Semiconductors, Kyoto, Japan, Sept. 8-13, 1966) *J. Phys. Soc.* **21**, Suppl., 32-36 (1966).

Exposure rate measurements of x- and gamma-rays with silicon radiation detectors, K. Scharf, *Health Phys.* **13**, No. 6, 575-586 (June 1967).

Ferromagnetic iron alloys lacking a hyperfine field at the iron site, L. H. Bennett and L. J. Swartzendruber, *Phys. Letters* **24A**, No. 7, 359-360 (Mar. 27, 1967).

Future spectroscopy for late-type stars, C. E. Moore, Proc. Colloquium on Late-Type Stars, Trieste, Italy, June 13-17, 1966, pp. 15-24 (Stampato Presso, Trieste, Italy, 1967).

High purity powdered CsI as a high reflectance infrared diffuser, J. Geist, G. J. Kneissl, and V. R. Weidner, *Appl. Opt.* **6**, No. 7, 1280-1281 (July 1967).

\*Publications for which a price is indicated are available by purchase from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign postage, one-fourth additional). The NBS non-periodical series are also available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151. Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

## CLEARINGHOUSE BIBLIOGRAPHIC JOURNALS\*\*

*U.S. Government Research & Development Reports.* Semimonthly journal of abstracts of R&D reports on U.S. Government-sponsored projects and list of current projects. Annual subscription (24 issues): Domestic, \$30; foreign, \$37.50. Single copy, \$3.

*Government-Wide Index to Federal Research & Development Reports.* Companion publication to preceding; semimonthly index to reports and projects announced in Nuclear Science Abstracts, Scientific & Technical Aerospace Reports, Technical Abstract Bulletin, and U.S. Government Research & Development Reports. Annual subscription (24 issues): Domestic, \$22; foreign, \$27.50. Single copy, \$3.

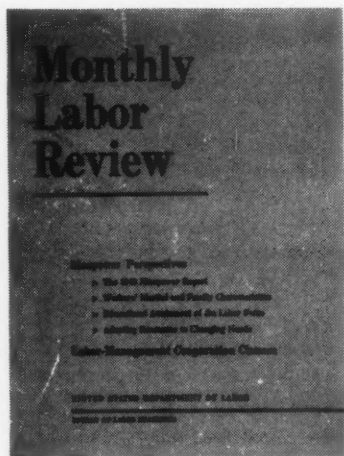
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